Net-Zero Energy Building Application In Neo-Vernacular Architecture Concept

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Abstract — Net-Zero Energy Building (NZE B) is an ideal concept which can answer the problem of the climate change in the field of architecture. The purpose of the research is to analyze the use of technological innovations in the concept of Net-Zero Energy Building in Neo-Vernacular architectural buildings without damaging the traditional elements that exist in the building. Neo-Vernacular Architecture approach is an approach that contains traditional theme but not limited in the use of new technologies or in building forms. The research was conducted by a comparative method of several buildings using Neo-Vernacular architectural concepts but also applying a number of things related to climate and environment, to be associated with the concept of Net-Zero Energy Building (NZE B). The results of this study explain the application of technology in NZEB can be applied to the Neo-Vernacular concept. But, not every Neo-Vernacular building using all NZEB technology, because it depends on its region and environment. Neo-Vernacular concept doesn’t limit its architect for maximizing the use of NZEB technology with a focus for its building not only minimalizing the use of energy but also can produce the energy reciprocity in accordance with its energy use.

Index Terms — Climate, Environment, Neo-Vernacular, Net-Zero

INTRODUCTION

Net-Zero Energy Building (NZE B) is a concept in the form of world idealism that has not yet reached the perfect stage, but every 5 years it always has a new target in its application throughout the world due to its own goals to respond the Climate Change crisis. Net-Zero Energy Building (NZE B) is applied with the latest modern technology and innovation both in structures, systems or materials in buildings. Neo-Vernacular concept is one Architectural Approach that also has a focus on responding to a climate and utilizing the surrounding environment. Although this approach is the development from Vernacular and Traditional concept, the Architect is allowed to applied and modify the technology system to the buildings. The discussion above has one similarity in how both concepts applied to buildings and both are using technology and innovation to its building for responding to the surrounding environment. This research discusses the ability of Net-Zero Energy Building idealism to be applied to buildings with Neo-Vernacular concepts, and the extent to which Net-Zero Energy Building benchmarks can be applied to Neo-Vernacular building criteria by analyzing theories and studies on NZEB and Neo-Vernacular and also the comparative analysis of buildings that apply the Neo-Vernacular concept. Climate change has been defined as variations in change over time in aspects of the weather element, due to human activity or natural vulnerability. Climate change has become a global concern and its effects continue to influence, threaten human life and largely affect the lives of many people around the world [1]. Dealing with climate change involves two approaches: Mitigation and Adaptation. Mitigation must focus on the need to reduce greenhouse gas emissions. Instead, Adaptation plans to adapt to the new status quo where the effects of climate change are counted in everyday planning decisions [2]. Net-Zero Energy Building is one of the solutions in development that can support aspects of Mitigation. As stated by the US Department of Energy (DOE): "Net zero-energy building is a commercial or residential building with a significant reduction in energy than energy income so that energy balance can be achieved with a renewable energy strategy." [3]. Adaptation aspects can be applied with Neo-Vernacular Architecture concepts in buildings. Basically, vernacular architecture, which consists of shelters and other types of buildings, is usually built by the community in relation to the environmental context and available resources, and by using traditional [4]. Vernacular Architecture, with all aspects of nature-friendly and all environmental features and community benefits, can join new green material technology to produce alternative construction technology, creating Neo-Vernacular building technology by increasing features that can be updated from vernacular building technology that can be taken from what was mentioned before. Therefore, this paper is intended to discuss that the NZEB technology approach is could be maximally applied to the Neo-Vernacular concept. However, some considerations should be taken into the application of NZEB technology to buildings. The research method used is to analyze two different theoretical frameworks, namely a theory containing a study of technological approaches to NZEB and Neo-Vernacular, and a study of building precedents with Neo-Vernacular concepts that use several technological innovations in buildings. The results of the precedent show buildings that use NZEB technology and on what grounds to use them. The buildings used as precedents were taken from several regions that have different climatic conditions and different cultural backgrounds. The results of this study will produce a theory about the ability of the Net-Zero Energy Building technology to be applied to buildings with the Neo-Vernacular concept.

2. THEORETICAL BASES

The Net-Zero Energy Building has many different theories due to the lack of and diverse understanding of the NZEB concept. According to one widely cited publication, the Net-Zero Energy Building is a residential or commercial building with a reduction in energy requirements so that the energy needs can be replaced with renewable technology [3]. In another sense, the Net-Zero Energy Building (NZE B) is a
building that can meet the rest of its energy needs through renewable technology. Zero is the point where buildings no longer consume energy but produce energy. At the zero points, the amount of energy needed flows the same as the amount of energy flowing out [5]. There are four definitions used for NZEB, the first is the Net-Zero Source Energy Building which is a source of energy produced by ZEB that must be as much energy used for one year. Energy sources refer to the primary energy used to produce and transmit energy into the site. The second is the Net-Zero Site Energy Building which is the ZEB site that is produced must be as much energy used for one year. The third is the Net-Zero Energy Cost Building, which is the amount of money a building owner pays for building energy exports on the electricity network must be equal to the amount that the building owner pays for service and is used within one year of building use. Fourth, the Net-Zero Energy Emission Building is zero-emission that is produced equivalent to emission-free renewable energy used for the emission-production of energy sources [3]. Technology is an important role to achieve net-zero building ideals. This technology has a variety of applications in terms of climate change, architectural design and preferences, building types, project goals, target audiences, etc. In this case, to narrow and focus the discussion, only technology, which can be applied to buildings, needs to be considered. The optimal strategy to achieve NZEB is to combine energy efficiency measures with renewable energy supply. This section will explain the principle and show how energy use in buildings can be reduced through energy efficiency, and also explains the technology that can be used as a solution in a building to replace all energy with renewable energy. The orientation and shape of the building also influence the NZEB. Buildings with a longitudinal orientation to the north-south have great potential to get excessive solar heat in non-hot seasons and have the advantage of getting solar heat in winter [9]. A large window area must be placed on the wall with an orientation towards the equator to maximize Passive Solar’s income [3]. The size of the building also affects the energy needs of a building. A building with two floors will be more efficient than a one-story building because the exterior envelope of buildings per unit size is smaller than the interior space [7]. Furthermore, a sophisticated insulation system, the main function of sophisticated insulation of a building is to minimize heat loss through exterior elements (for example walls, windows, roofs), which can eliminate 50% of the total heat in buildings. The types of various building insulation are, Fiberglass Batts, Mineral Fiber Batts, Foam, Wood, and Vacuum Insulation Panels [8]. Reduction in Thermal Bridging also plays an important role in reducing heat in buildings by a significant amount, although several measurements must be determined to reduce the heat. Thermal Bridging is the movement of heat on an object that is more conductive compared to other material elements. Next is the Airtight, to improve airtightness through the ‘single airtight veil principle’. This principle requires the building envelope to ‘cover the entire interior space’. This can be achieved by applying a variety of technologies for the isolation and prevention of air leaks, such as Internal Plastering (Lime Plaster, Lime-Cement Plaster, Gypsum Plaster, and also Reinforced Loam Plaster); Plywood Board, Hardboard, and Particle Board [9]. The use of Thermal Mass is also the ability for building material to store heat. The main interest of materials with Thermal Mass for energy efficiency is the ability of these to suck up the heat, store and release them [5]. The use of sophisticated windows is also one of the systems in energy efficiency because it functions as solar lighting, the introduction of solar heat, and the reduction of heat in buildings. By using sophisticated windows that are optimal, will reduce the use of electrical energy. Shading is also one of the systems in energy efficiency, which has a function as a protection in the transmission of solar heat in a building [7]. On the roof, used Cool Roof which is a Solar-Reflective roof that absorbs less solar heat than conventional roofs. The level of light reflection is greater if using a brighter roof color and using materials that reflect and emit light so that it can reflect about 60% of sunlight compared to using a regular dark roof that only reflects 10-20% of sunlight [9]. Ventilation strategies should also be considered for energy efficiency systems because these strategies affect the temperature and humidity of the air in a building. There are two strategies that can be applied, namely Natural Ventilation and Forced Ventilation. Furthermore, each of these technologies can be applied to the building simultaneously. However, buildings that apply traditional concepts need to be considered in this regard. The Neo-Vernacular Architecture concept is a concept that makes it possible to continue to apply the technological approach to NZEB. Vernacularism is a relationship and the ability to adapt from forms that are built with social, economic, ecological, and climate environments. The Vernacularism approach uses traditional technology and the use of local materials, which connect the two with the natural environment. This is due to revive building traditions based on certain cultures and communities. Vernacularism Interpretative, or Neo-Vernacularism, tries to bring something new to the Vernacular approach. However, the Neo-Vernacularism approach utilizes various levels of technology and new types of infrastructure, such as heating, cooling, and other technical services [5]. Neo-Vernacular Architecture starts from the basic principle of human development which has reached the stage of the ‘Ecological Principle’. Ecological Era aims to revitalize a living world where life forms are influenced by existing resources. This era does not reject science and technology but aims to unite the two [11]. One of the roles of Neo-Vernacular is as a reminder of the past, to provide symbols for residents and visitors of a place that gives an understanding of what the specific place means from time to time [17]. This can be considered a form of preservation in terms of commemorating people or past events, giving some emphasis in history through physical form, appreciating age as a concept, using the past in new contexts to give identity to that place, maintaining existing identities. Neo-Vernacular has the basic principles of Vernacular Architecture, usually built by the community in relation to the environmental context and available resources, and by using traditional technology [3]. The author believes that with adaptation in the present or future time, Vernacular Architecture, with all aspects of environmentally friendly and all environmental features and benefits of society, can join with new green material technology to produce alternative construction technologies, creating ie Neo-Vernacular building
technology; This is done by enhancing the renewable features of vernacular building technology that can be taken from what was previously stated. The principles that need to be considered in Neo-Vernacular Architecture are minimizing changes in existing/natural to maintain the natural environment in the construction area, the use of natural resources in the area of development, Providing a harmonious visual between the dynamics of Architecture & Nature, Participation of local people in the construction process, and combining traditional construction methods with modern ones.

3. DISCUSSION

Based on the study of the two theoretical frameworks above, several buildings that apply the Neo-Vernacular concept can be seen as how many applications of NZEB technology are used in the building. The Jean-Marie Tjibaou Cultural Center building, located in New Caledonia, France, was designed by architect Renzo Piano to apply the concept of Neo-Vernacular architecture. Piano applies the concept because the island of New Caledonia is an island that has a thick traditional culturated population called the Kanak tribe. They have beliefs and traditions in carrying out daily life. The piano built this building using local materials in the area. The figure of Jean-Marie Tjibaou

![Fig. 1. Jean-Marie Tjibaou Cultural Centre](Source: Archdaily)

Cultural Centre is shown in figure 1. This building orientation concern the direction of the wind from the east that comes from the sea for utilizing the air circulation, sunlight, and solar heat. For insulation, the building used local material like wood from the existing place, concrete, coral, aluminum castings, glass panels, and stainless steel. The roof is using wave aluminum sheets and has a double roof system. The ventilation strategy that is used is to utilized the circular building shaped like a shell with a high ratio building with minimalizing the diameter so the building gives much space that provides bigger dynamic ventilation. The next project is a school in Chuquibambila, Peru designed by the architect Paulo Alfonso, Marta Maciąglnia, Ignacio Bosch, dan Borja Bosch. This building applied Neo-Vernacularism because it still considering using the style and material from its country. This building was built by the people because it has common goals to answer the lack of education facilities for children there. Climate comfort is achieved through the use of passive systems, with particular attention to sunlight control, ventilation, and natural lighting, reducing energy requirements to a minimum. The computer room is powered by solar panels. Gray water is treated and reused for irrigation of green areas as shown in figure 2.

![Fig. 2. School in Chuquibambilla](Source: Archdaily)

Next project is Bamyan Provincial Hospital in Afghanistan, built by Arcop (Pvt) Ltd. It draws inspiration from the traditional methodologies of the built environment, and the simplicity of forms seen in the local vernacular in the context of home and village settings. A North-South orientation is developed to maximize solar gain in winter and optimize daylighting. Through this strategy, light is brought into all the corridors and wards. The building insulation made by stabilized rammed along with RCC frame construction built using the technique adopted by the traditional building method. Overall, their attempt is to take a “biophilic” approach to design, where through natural light and ventilation. The almost non-existent nature of infrastructure in Bamyan, the architect relied on Sustainable Design Practices, such as; natural lighting and ventilation, achieving high insulative values, mass thermal, recycling greywater and developing landscape sensitive to the natural aridity of the region. Solar power is used as the main energy source for the hospital since there is no provision for electricity in town. The figure of Bamyan Provincial Hospital is shown in figure 3.

![Fig. 3. Bamyan Provincial Hospital](Source: Archdaily)

Last, Bio-Climatic Preschool in Morocco designed by BC Architects. This building built with a Bioclimatic concept with Neo-vernacular approach on the typology, materials, and local technique with contemporary display, bioclimatic and earthquake-resistant building design. The southeast and northwest façades which have harsh low-sun impacts are protected by tree or courtyard shadows, while the south façade has a cavity wall for insulation and a big thermal mass, making the building cool during the day, but warmer through the night until the morning. The figure of Bio-Climatic Preschool is shown in figure 4. For further analysis
of NZEB and Neo-Vernacular, the table analysis is shown in table 1.

![Fig. 4. Bio-Climatic Preschool](Source: Archdaily)

Building Mass & Orientation, two out of four buildings considered the building orientation for utilized sunlight and seasonal changes. This consideration needs to look at the climate in its region. The primary purpose of considering the building orientation is for sunlight and solar heat gain in the building. Usually, a building located on a winter region annually will orient the building towards the sun so the building will gain enough solar heat. Three out of four buildings considered building insulation components, even though the NZB primary material not used on the building, but the material used still considered a good impact material for the surrounding environment. This based on utilizing the natural resources in the region but also gave a positive impact for the surrounding environment. Two out of four buildings considered Thermal Mass component, this thing prioritized for absorbing heat inside the building by its material and support temperature optimizing inside the building every day. Usually, the use of Thermal Mass considered in the hot area.

Table 1. NZEB Analysis of Neo-Vernacular Buildings.

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Bio-Climatic Preschool, Morocco</th>
<th>NZEB &amp; Vernacular Concept</th>
<th>NZEB &amp; Vernacular Concept</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Neo-Vernacular</strong></td>
<td>Traditional methods of the built environment, simplicity of forms in local vernacular in the context of home and village settings.</td>
<td>Based on Kanak Tribe's cosmologic beliefs.</td>
<td>Using Local Material.</td>
</tr>
<tr>
<td><strong>Energy Efficiency</strong></td>
<td>Nothing in particular</td>
<td>Nothing in particular</td>
<td>Nothing in particular</td>
</tr>
<tr>
<td><strong>Building Mass &amp;</strong></td>
<td>Nothing in particular</td>
<td>A North-South orientation is</td>
<td>Nothing in particular</td>
</tr>
<tr>
<td><strong>Ventilation Strategies</strong></td>
<td>Nothing in particular</td>
<td>Nothing in particular</td>
<td>Nothing in particular</td>
</tr>
</tbody>
</table>

Advanced Windows applied on one out of four-building, even though the NZB primary material not used on the building, but the building used a double glass window to reduce the solar heat inside the building. Roof component only used on one out of four buildings and not using NZEB primary materials, but the same as the windows component, the materials could control absorb and release solar heat in the building. Last, the Ventilation component used by three out of four buildings, this component is very considered to be used on the Neo-Vernacular concept, Ventilation will provide better wind and natural air inside the building and efficient energy on the building. But, some of the components mentioned in the NZEB technology approach are not used in buildings like Thermal Bridging, Airtight, and Shading.

4. CONCLUSION

Based on the analysis and study of several building examples, the Neo-Vernacular Architecture concept has an outline similar to NZEB, namely the use of the environment, the impact on the environment, and also the climate. Therefore, all technological approaches to NZEB can be applied to the Neo-Vernacular concept. But the Neo-Vernacular concept in one building does not mean using the entire technological approach to NZEB, because it returns to the existing climate and environmental conditions. In buildings in cold areas, most use technology that can warm the building by minimizing energy use, while buildings in hot areas use technology that can make the building use the wind in the area. Buildings with Neo-Vernacular concepts have not yet maximized the use of technology that can provide energy out of the building such as in NZEB, but there is still a need for further research.
as the completion of the NZEB concept, but still, focus on minimizing energy use or damaging the surrounding environment. Even so, the Neo-Vernacular concept does not limit architects to maximize the use of NZEB technology with a focus so that the building not only minimizes the energy used but can produce energy reciprocity equivalent to the use of its energy.

REFERENCES